# Analyzing digital images as a means to identify climatic influences on plant-level phenology

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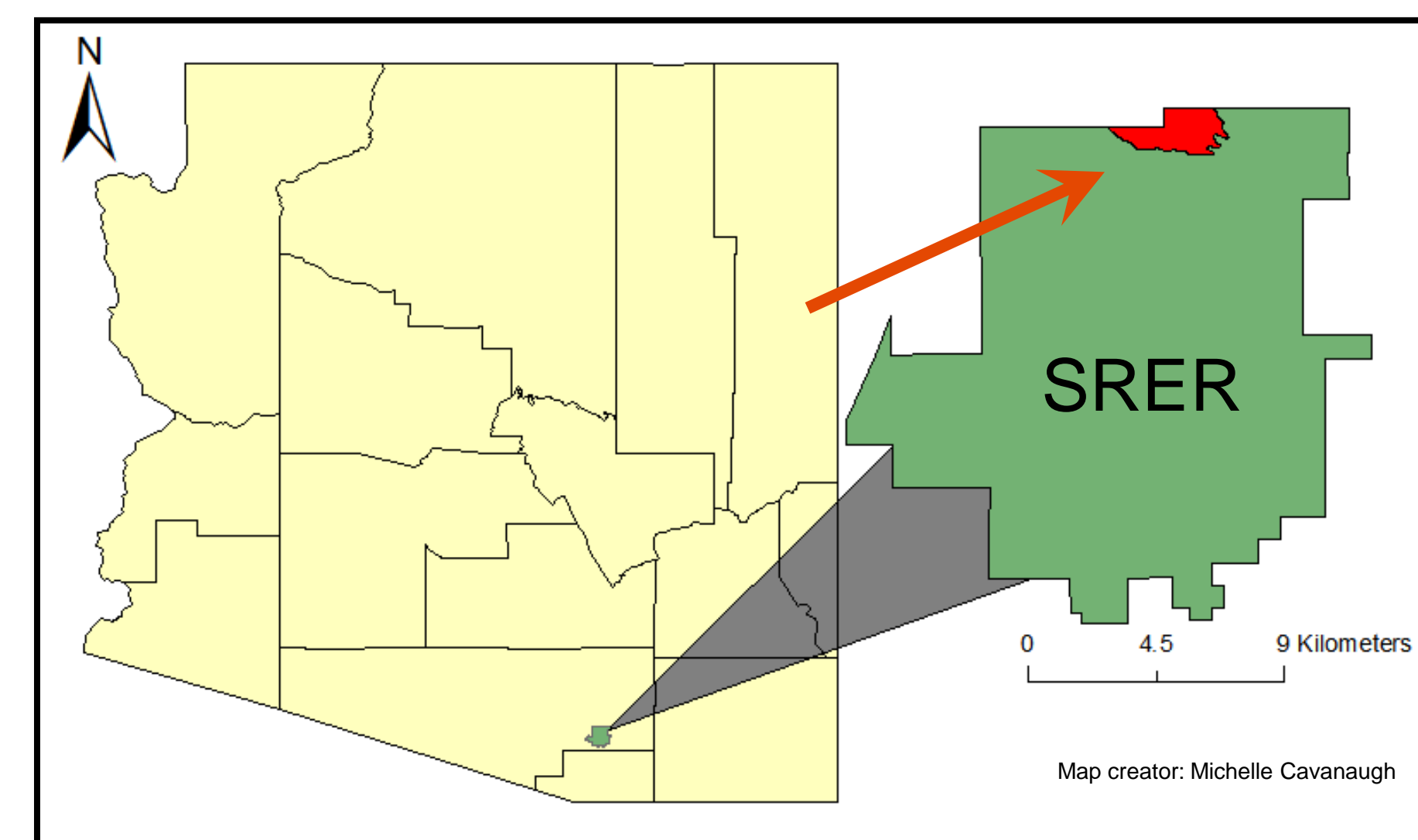lmbenton@email.arizona.edu, kurc@ag.arizona.edu

1 Introduction

In the coming future, the southwest U.S. and northwest Mexico region is predicted to undergo a change in climate that will create drier, warmer conditions than presently exist (Seager 2007). As a result of this climate alteration, it can be expected that plant phenological activity (seasonal timing of biological events such as plant growth and flowering) will also be affected throughout this region. The most dominant and extensive shrub species of the warm desert ecosystems of North America is the creosotebush, *Larrea tridentata* (see map to left). Consequently, creosotebush has a major impact on the structure, functioning, and flow of resources (i.e., carbon, water, and energy) in these regions, and when in bloom serves as an abundant and reliable food source for hundreds of pollinating insects that synchronize their emergence with flowering time (Cane et al. 2005). In this study, we focus specifically on the reproductive phenology of creosotebush. By gaining a better understanding of the phenological "triggers" that initiate reproduction and plant growth in the widespread creosotebush, we can come to understand how these water-limited ecosystems might respond to climate change and in turn how we may be able to effectively manage resources in this region.
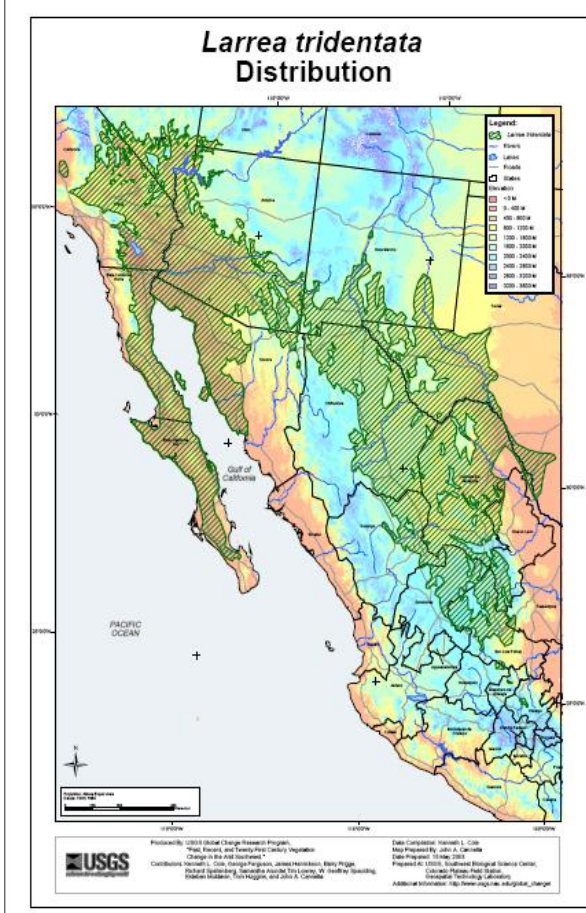
2 Site Description

This site was chosen because it is representative of creosotebush regions in the Sonoran Desert, with diversity in size among individuals in the population and extensive areas of bare ground between plants. The site is also co-located with an eddy covariance tower, which allows for carbon fluxes and ecosystem-level evapotranspiration to be incorporated into the results.

❖ Mean annual precipitation: 288 mm
❖ Soil type: sandy loam
❖ Mean temperature range: 11-24℃

Field site within the Santa Rita Experimental Range (SRER)

Eddy Covariance Tower

3 Hypothesis

Frequency, duration and abundance of flowers in the repeat-blooming creosotebush are regulated by:

(1) temperature during the spring

(2) soil moisture below the depth of atmospheric demand in the summer

4 Methods

❖ 6.0-megapixel Moultrie I-60 digital cameras (3 each) within the footprint of the eddy covariance tower taking 1 picture every hour sites with varied patch size and height distributions

❖ Continuous measurements of precipitation, air temperature, soil temperature, and net radiation

❖ Eddy Covariance tower instrumentation (standard set-up)

❖ Soil Moisture Probes (water content reflectometers under bare and canopy surfaces) at 2.5, 12.5, 22.5, 37.5, 52.5, 67.5, and 82.5 cm depths

❖ Pre-dawn plant water potential taken pre-monsoon, mid-monsoon, and post-monsoon (monthly intervals)

5 Image Analysis

First sign of spring bloom — *Spring peak bloom* — *Pre-monsoon water stress* — *Mid-monsoon peak bloom*

Images taken within the time frame of 11AM-1PM were selected for each camera, depending upon amount of cloud shading and solar angle throughout the year. While image analysis will soon be automated, initial analysis was carried out via visual inspection to produce a 'Blooming Calendar' (shown in charts below). Automation techniques for daily images are being developed with the MATLAB Image Processing Toolbox 6.2 (The Mathworks, Inc.)
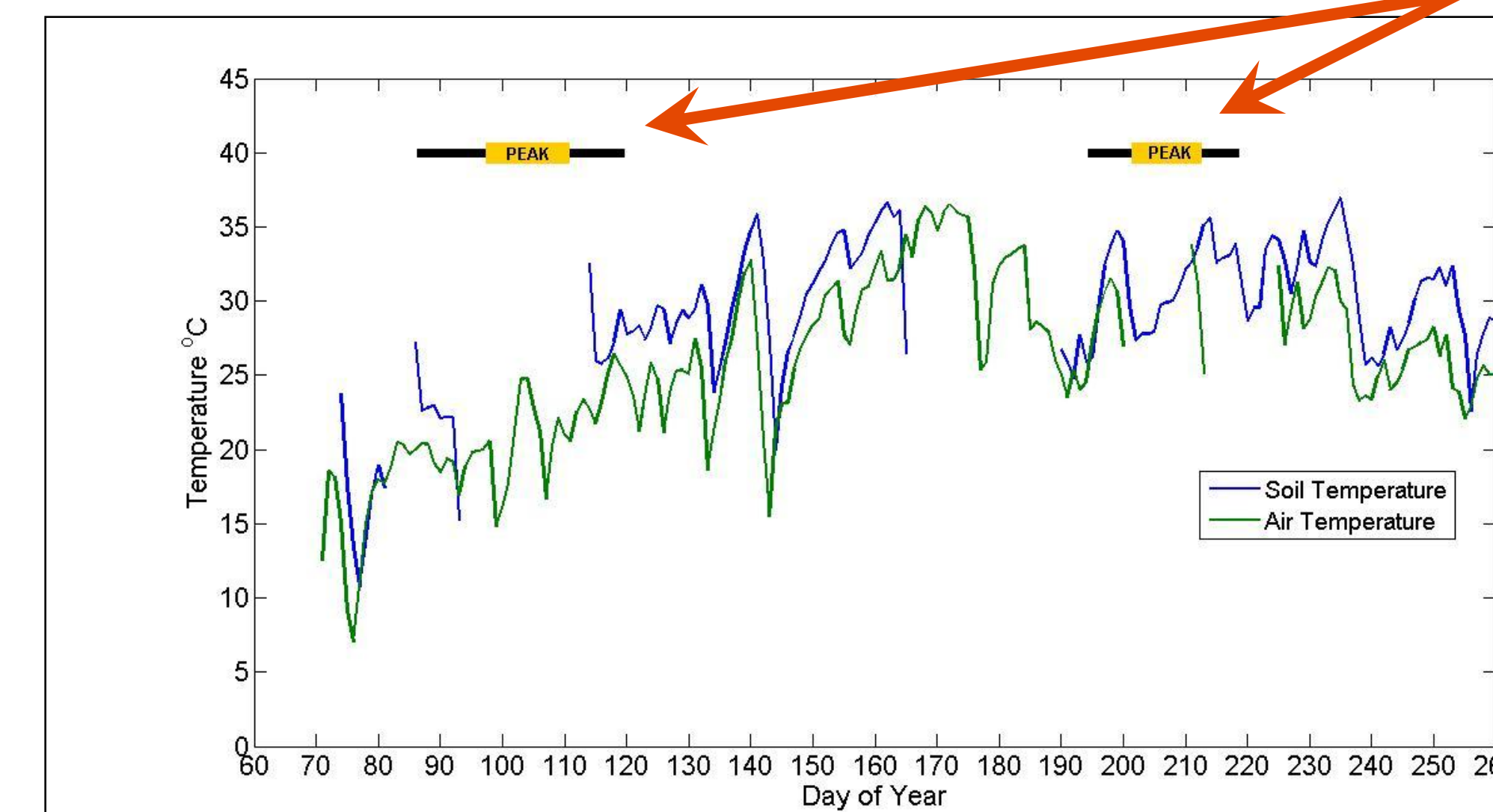
6 Preliminary Results

Chart 1: *Soil & Air Temperature plotted against Bloom Events at SRER study site*:
❖ In prior days to both blooming events, temperatures dropped approximately 10℃
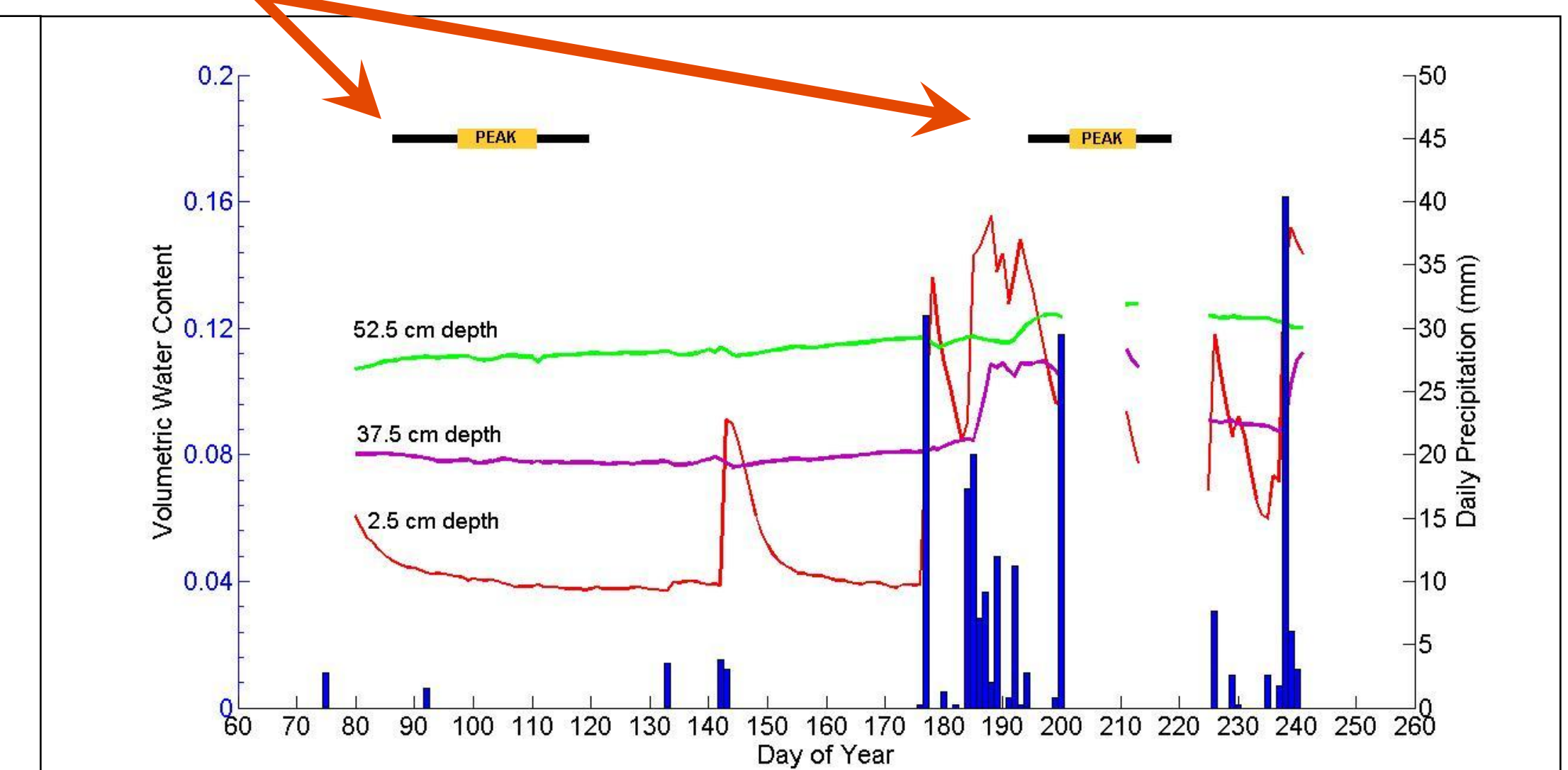❖ Neither air temperature or soil temperature is enough at this point. We have to look more closely

Chart 2: *Soil Moisture, Precipitation, and Bloom Events of SRER study site*:
❖ Sustained deep soil moisture (37.5 cm) above a certain threshold (~0.13) was required to trigger bloom
❖ Depths of 52.5 cm and beneath were not greatly affected by monsoon precipitation (67.5 cm and 82.5 cm depths plotted similar results)
❖ Anxious to observe potential third blooming period in 2008, and to capture soil moisture and precipitation records prior to Spring 2009 bloom event

7 Future Work

❖ Calculation of degree days (heat units) leading up to flowering and peak flowering events

❖ Automated image analysis ("yellow index") to quickly and effectively examine numerous daily images in relation to climate variables

❖ Analysis of bud development period prior to bloom events

❖ Further investigation of individual flowering phenophases (first flower, first date of peak flower, last flower)

References

Cane, J. H., R. Minckley, et al. (2005). "Temporally persistent patterns of incidence and abundance in a pollinator guild at annual and decadal scales: the bees of *Larrea tridentata*." *Biological Journal of the Linnean Society* **85: 319-329.**

Seager, R. (2007). Abrupt climate change and early warning systems: The case of imminent drying of the U.S. Southwest. *The Climate Research Committee of the National Research Council, National Academies of Sciences*, Washington, DC, Lamont Doherty Earth Observatory of Columbia University.